

CENTRAL INTELLIGENCE AGENCY	REPORT
INFORMATION FROM	
FOREIGN DOCUMENTS OR RADIO BROADCASTS	CD NO.

COUNTRY	USSR
SUBJECT	Scientific - Geophysics, petroleum
HOW PUBLISHED	Book
WHERE PUBLISHED	Moscow
DATE PUBLISHED	1949
LANGUAGE	Russian

DATE OF INFORMATION 1949

DATE DIST. 6 Oct 1950

NO. OF PAGES 7

SUPPLEMENT TO  
REPORT NO.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANINGS OF ESPIONAGE ACT 50 U.S.C., 31 AND 32, AS AMENDED. ITS TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW. REPRODUCTION OF THIS FORM IS PROHIBITED.

THIS IS UNEVALUATED INFORMATION

SOURCE Podzemnaya Gidravlika, Gostoptekhnizdat,

50X1-HUM

ABSTRACT OF PROFESSORS V. N. SHCHELKACHEV AND B. B. LAPUK'S BOOK  
"UNDERGROUND HYDRAULICS"

This book, edited by Academician L. S. Leybenzon and authorized by the Ministry of Higher Education USSR as a textbook for higher petroleum schools, is the first text published as a school course on underground hydraulics since 1941. It stresses the priority of Soviet scientists in solving important problems concerning the movement of fluids and gases in porous media. To this category belong problems on the theory of filtration, interaction of oil wells, elasticity, movement of gases, and gaseous fluids in strata. The book generalizes previous findings in the field of underground petroleum hydraulics.

The book is intended both for students in higher educational institutions specializing in petroleum and for engineers and technical workers in the petroleum and gas industries.

## TABLE OF CONTENTS

(Sections marked with an asterisk are not obligatory in a school curriculum.)

	<u>Page</u>
Editor's Preface	3
Preface	4
 <b>PART I. INTRODUCTION</b> 	
Chapter I. Summary of a Course in Underground Hydraulics and Important Stages of Its Development	7
1. Underground Hydraulics as a Technological Basis for the Extraction of Petroleum and Gas	7
2. Short Summary of the Most Important Stages in the Development of Underground Hydraulics	10

- 1 -

**CONFIDENTIAL**

CLASSIFICATION      CONFIDENTIAL

STATE		NAVY		NSRB		DISTRIBUTION	
ARMY		AIR		FBI			

**CONFIDENTIAL**

CONFIDENTIAL

50X1-HUM

	<u>Page</u>
Chapter II. Fundamental Principles of Underground Hydraulics	12
1. Development of Ideas Contributing to the Generalization of Technological Problems Involved in the Extraction of Petroleum and in Underground Hydraulics	12
2.* Observations on the Interaction of Oil Wells and Deposits	16
3.* Concise Data on the Classification of Underground Water	20
4. Concise Data on the Classification of Processes in Petroleum-, Gas-, and Water-Bearing Strata	23
5. Typical Systems and Patterns of Stratified Water-Pressure Systems	28
Chapter III. Short Description of the Properties of Fluids and Gases	34
1.* Properties of Petroleum	34
2.* Properties of Water Occurring in Petroleum Strata	43
3.* Properties of Gases in Petroleum and Gas Deposits	45
PART II. THEORY OF FILTRATION	
Chapter IV. Fundamental Ideas	50
1. Definition and Peculiar Properties of Filtration. Ideal and Fictitious Soils (for Modeling)	50
2. Porosity and Spacing of Fictitious Soil	52
3. Transition From Fictitious to Natural Soil	57
4. Rate of Filtration and Its Relation to Rate of Flow	59
Chapter V. Theoretical Formulas Describing the Laws of Filtration of Fluids With a Generalization of These Formulas	62
1. Laws of Filtration Through Fictitious Soils	62
2. General Expression for Various Theoretical Formulas Describing the Law of Filtration	65
Chapter VI. Linear Law of Filtration. Permeability of Porous Media	67
1. Darcy's Experiments. Coefficient of Filtration	67
2. Permeability of Porous Media	71
Chapter VII. Limits to the Applicability of Darcy's Law; Other Laws of Filtration	78
1. Experimental Research on the Limits to the Applicability of the Linear Law of Filtration	78
2. Theoretical Research on the Limits to the Applicability of the Linear Law of Filtration	84
3. Nonlinear Laws of Filtration	87
4. Deductions From the Laws of Filtration Based on the Principle of the Homogeneity of Dimensions	89

- 2 -

CONFIDENTIAL

**CONFIDENTIAL**

**CONFIDENTIAL**

CONFIDENTIAL

50X1-HUM

	<u>Page</u>
PART III. PROBLEMS IN UNDERGROUND HYDRAULICS SUSCEPTIBLE TO SIMPLE SOLUTION	
Chapter VIII. Simplest Forms of Filtration Flow and Methods of Studying Them	94
1. Description of the Simplest Forms of Filtration Flow	94
2. Head and Reduced Pressure; Surfaces With Equal Head and Isobars	98
3. General Methods of Studying One-Dimensional, Plane-Radial and Three-Dimensional, Radial Flow	100
Chapter IX. One-Dimensional and Radial Flow of Incompressible Fluids Under Water-Pressure Conditions	103
1. One-Dimensional Flow According to the Linear Law of Filtration	103
2. Plane, Radial Flow According to the Linear Law of Filtration	108
3. Spherical, Radial Flow According to the Linear Law of Filtration	121
4. One-Dimensional Flow in Accordance With the Non-linear Law of Filtration	125
5. Radial Flow in Accordance With the Nonlinear Law of Filtration	126
6. Peculiarities of the Flow of Fluids Into Wells When There Are Two Simultaneous Processes of Filtration in a Stratum	129
7. The Influence of Pressure Changes in the Course of Time	133
Chapter X. The Simplest Cases of the Flow of a Fluid With a Free Surface	135
1. Introductory Remarks	135
2. Flow of a Fluid With a Free Surface Toward a Rectilinear Gallery	136
3. Flow of a Fluid With a Free Surface Toward Wells	140
Chapter XI. One-Dimensional and Radial Flow of a Compressible Fluid in a Porous Medium in Accordance With the Linear Law of Filtration	147
1. One-Dimensional, Steady Filtration of a Compressible Fluid	147
2. Radial, Steady Filtration of Compressible Fluids	152
3. Approximate Solution for the Problem of Nonsteady, Radial Filtration of Compressible Fluids	154
4. Nonsteady, One-Dimensional Filtration of Compressible Fluids	162
5. Approximate Solution for the Problem of the Nonsteady Flow of Compressible Fluids in Porous Strata	165

- 3 -

CONFIDENTIAL

**CONFIDENTIAL**

**CONFIDENTIAL**

CONFIDENTIAL

50X1-HUM

	<u>Page</u>
Chapter XII. One-Dimensional and Radial Flow of Gases in Porous Media	167
1. Law of Filtration of Gases. Experimental Studies on the Flow of Gases in Porous Media	167
2.* Thermodynamic Processes During the Flow of Gases in Porous Media	170
3. One-Dimensional, Steady Flow of Gases According to the Linear Law of Filtration	176
4. Radial, Steady Flow of Gases According to the Linear Law of Filtration	181
5. Nonsteady, Radial Flow of Gases According to the Linear Law of Filtration	190
6. Steady Gas Flow Not Subject to the Linear Law of Filtration	200
7. Flow of Real Gases in Porous Media According to the Law of Filtration	208
Chapter XIII. Flow of Heterogeneous Fluids in Porous Media	217
1. Introductory Remarks	217
2. Phase (Effective) Permeability of a Porous Medium	219
3. Steady Flow of a Gaseous Fluid in a Porous Medium	225
4. Nonsteady, Radial Flow of a Gaseous Fluid in a Porous Medium	233
5. Flow of a Mixture of Petroleum and Water in a Porous Medium	244
6. Flow of a Mixture of Petroleum, Water, and Gas in a Porous Medium	249
Chapter XIV. Influence of the Radius and Degree of Hydrodynamic Imperfection of Wells on Their Productivity	256
1. Influence of the Radius of a Well on Its Productivity	256
2. Influence of the Hydrodynamic Imperfection of a Well on Its Productivity	268
Chapter XV. Certain Problems Connected With the Study of Wells Through Their Inflow	285
1.* Introductory Remarks	285
2.* Laws Governing Changes in Drill-Hole Pressure in a Well After Shutdown	285
3.* Factors Influencing the Form of Indicator Curves When Operating Conditions in a Well Are Stable	289
4.* Classification and Analytical Expression of Indicator Curves	292
5.* Most Important Characteristics of the Productivity Factors of Wells	296
6.* Observations on Research Methods for Wells	301
Chapter XVI. Influence of the Difference in the Specific Gravity of Two Fluids in a Stratum on the Pressure Distribution and Behavior of a Well	305
1. Analysis of the Phenomenon of the Rise of Bottom Water to the Face of an Oil Well	305
2.* Remarks on Certain Hydrogeological Problems	310

- 4 -

CONFIDENTIAL

**CONFIDENTIAL**

**CONFIDENTIAL**

CONFIDENTIAL

50X1-HUM

	<u>Page</u>
Chapter XVII. Flow of Fluids and Gases in Strata With Nonuniform Permeability	312
1.. Introductory Remarks	312
2. One-Dimensional Flow of Fluids in Nonuniform Strata	319
3. Plane-Radial Flow of Fluids in Nonuniform Strata	319
4.* Influence of the Nonuniformity of a Stratum on the Flow of an Incompressible Fluid According to Krasnopol'skiy's Law of Filtration	328
5. Generalization of the Foregoing Conclusions	332
Chapter XVIII. Displacement of Oil and Gas by Water	335
1. One-Dimensional Problem in the Displacement of Oil by Water	336
2. Displacement of Oil by Water During Plane, Radial Flow	344
3. One-Dimensional Problem in the Displacement of Gas by Water	350
4. Displacement of Gas by Water Under Radial Filtration Conditions	357
5. Remarks on the Influence of the Viscosity of a Gas on the Advancement of Water-Bearing Contours During Displacement of Gas by Water	364
PART IV. NONRADIAL FLOW OF FLUIDS AND GASES TOWARD ONE WELL AND THE THEORY OF THE INTERACTION OF WELLS (PROBLEMS SOLVABLE BY HYDROMECHANICAL METHODS)	
Chapter XIX. Study of Filtration Flow From a Pressure Well to an Exploited Well and Study of Nonradial, Steady Flow of Fluids and Gases Toward One Well. Explanation of the Influence of the Shape of Contours of a Supply Area on the Yield of Wells and Distribution of Pressure in a Stratum	367
1. Remarks on the Statement of the Problems	367
2. Study of Filtration Flow From a Pressure Well to an Exploited Well	369
3. Nonradial Flow of Fluids Toward a Well When the Contours of the Supply Area Are Rectilinear	380
4. Nonradial Flow of Fluids Toward a Well When the Contours of the Supply Area Are Curved	381
5. Influence of the Form of the Contours of the Supply Area on the Yield of the Well. Remarks on the Possibility of Using the Formula for a Radial Inflow When the Flow of a Fluid to a Well is Nonradial	385
Chapter XX. Theory of the Interaction of Wells	389
1. Statement of Fundamental Problems	389
2. Basic Formulas Describing the Operation of Two Interacting Wells	395
3. Analysis of Families of Paths, Isobars, and Distribution of Filtration Rates in a Stratum in the Case of Two Interacting Wells	404

- 5 -

CONFIDENTIAL

**CONFIDENTIAL**

**CONFIDENTIAL**

CONFIDENTIAL

50X1-HUM

	<u>Page</u>
4.* Solution of the Simplest Problem Under Conditions Involving Capping of One of the Two Wells During the Course of Their Interaction	411
5.* Characteristics of Productivity Factors in Interacting Wells	412
6. Numerical Evaluation of the Interacting Effect of Two Wells	419
7. Interaction of a Circular Bank of Wells	422
8. Evaluation of the Interacting Effect of Many Wells When Disposed Along a Straight Line or in a Square Network	428
9.* Analysis of the Simplest Hydrodynamic Fields of Interacting Wells and Conclusions Regarding the Influence of Impermeable Stratum Boundaries on Their Operation	435
10.* Evaluation of the Interacting Effect of Wells in a Rectilinear Bank in the Presence of Impermeable Stratum Boundaries; Comparative Yield of Rectilinear <del>Channels</del> and Banks	441
 Chapter XXI. Simplest Laws Governing the Contraction of the Contours of Oil-Bearing Areas in Wells. Conclusions in Connection with Rational Methods of Well Spacing.	 447
1. Remarks on the Statement of Problems	447
2. Contraction of Oil-Bearing Contours of Different Shapes for One Well	448
3. Contraction of Oil-Bearing Contours for Two Interacting Wells	452
4.* Contraction of Oil-Bearing Contours for Wells in Circular Banks	485
5.* Peculiar Features of the Contraction of Oil-Bearing Contours Extended in an Oval for Wells Disposed Along the Long Axis of the Oval	463
6.* Peculiar Features of the Contraction of Oil-Bearing Contours for a One-Row Bank of Wells in a Stratum Closed on Three Sides	465
7.* A Few Ideas on the Spacing of Wells in Oil-Bearing Strata Under Water-Pressure Conditions	470
 PART V. DIFFERENTIAL EQUATIONS FOR UNDERGROUND HYDRAULICS. CONCLUSIONS	
 Chapter XXII. Differential Equations for the Flow of Fluids and Gases in Porous Media According to the Linear Filtration Law and Their Integration in the Simplest Cases	 474
1. Equation of Continuity During the Flow of Uniform Fluids and Gases in an Undistorted Porous Medium	474
2. Equation of Flow for Fluids Sufficiently Compressible to Form Drops and Incompressible Fluids in a Porous Medium Incapable of Distortion	477
3. Equations of Motion for Gases in a Porous Medium	484
4. Flow of a Gaseous Fluid in a Porous Medium	492

- 6 -

CONFIDENTIAL

**CONFIDENTIAL**

**CONFIDENTIAL**

CONFIDENTIAL

50X1-HUM

	<u>Page</u>
5. Differential Equation for the Flow of a Compressible Fluid in an Elastic Porous Medium	494
6. Analogy Between the Flow of Fluids and Gases in a Porous Medium and Other Physical Phenomena	497
Chapter XXIII.* Short History of the Development of Underground Hydraulics. Conclusions	501
Bibliography	510

- E N D -

- 7 -

CONFIDENTIAL

**CONFIDENTIAL**